Scram and Safety System Actuation Review

INTRODUCTION

During the annual review of industry trend performance indicator (PI) data, Idaho National Engineering and Environmental Laboratory (INEEL) reported that the 2003 automatic scram and safety system actuation (SSA) PIs exceeded their early-warning and action thresholds (see Table A4-1). These thresholds represent 95 and 99% prediction limits, respectively, developed from a baseline period (Fiscal Year [FY] 1997-2002 for scrams and 1999-2002 for SSAs).

Table A4-1. FY 2003 Scram and SSA data.

Indicator	FY 2003	Base Period Average	Early-Warning Threshold	Action Threshold
Automatic scrams	0.748/plant 77 scrams total	0.534/plant 55 scrams total	0.680/plant 70 scrams total	0.738/plant 76 scrams total
Safety system actuations	0.398/plant 41 SSAs total	0.241/plant 25 SSAs total	0.340/plant 35 SSAs total	0.388/plant 40 SSAs total
Equipment forced outage rate	0.157 outages per 1000 critical hours	0.131 outages per 1000 critical hours	0.157 outages per 1000 critical hours	0.166 outages per 1000 critical hours

Exceeding a single early-warning threshold is not uncommon, because this threshold is based on a 95 percent prediction limit. For each PI, the probability of exceeding warning-level and action level thresholds are 1/20 (5%) and 1/100 (1%), respectively, from random fluctuation. However, the probability of a PI reaching its early-warning threshold, and two other PIs exceeding their action thresholds from random fluctuation, without the influence of external factors, is extremely small (0.043%).

In response to this unusual PI activity, NRC requested that the INEEL perform an in-depth review of the scram and SSA data to identify any factors that may have caused the FY 2003 increase. This report contains the results of that review.

SUMMARY

Scrams

An increase in automatic scrams occurred in FY 2003 primarily due to grid-related problems.

SSAs

An increase in SSAs occurred in FY 2003. This increase resulted from the increase in total scrams (primarily automatic scrams). This change was not isolated to FY 2003. Although SSA numbers were decreasing before FY 2003, the number of SSAs associated with scrams was not decreasing. This resulted in an almost continuous increase in the percentage of SSAs that were associated with scrams. Thus, the increase in FY 2003 scrams resulted in a related increase in SSAs.

AUTOMATIC SCRAMS

INEEL conducted an analysis of the increase in the number of automatic scrams. The analysis included a review of the information listed below (similar data was also reviewed during the analysis of SSAs):

- scram causes (equipment, personnel error, or other)
- systems involved in equipment-related scrams (feedwater, turbine, generator, or other)
- activities in progress at the time the scram occurred (normal operation, maintenance, testing, or power changes)
- scrams by reactor type (PWR or boiling water reactor [BWR])
- the number of automatic scrams caused by problems associated with offsite power grid and/or the plants' interface with the grid
- a histogram of the number of plants that experienced different levels of scrams in a year

FY 2003 automatic scrams were at the highest level since FY 1996 (greater than any year in the FY 1997-2002 baseline period). The early-warning and action thresholds correspond to 70 and 76 scrams, respectively, for 103 plants (including Davis-Besse). In FY 2003, 77 automatic scrams occurred, exceeding the thresholds by 7 and 1 scrams, respectively; and exceeding the baseline period average (55) by 22 scrams (40%). It was noted that the August 14, 2003, Northeast blackout event resulted in 9 automatic scrams. Had this event not occurred, neither of the two thresholds would have been exceeded. However, the increase in FY 2003 automatic scrams would still be notable, exceeding the baseline period average by 13 scrams (24%).

Grid-related scrams rose dramatically in FY 2003; 23 scrams in FY 2003 compared to only 26 for the entire 6-year baseline period. The fact that FY 2003 grid-related scrams were 19 greater than the baseline period average accounts for most of the increase in FY 2003 automatic scrams.

Equipment failure continued to be the leading cause of automatic scrams, accounting for 48 (62%) of the FY 2003 automatic scrams. FY 2003 scrams due to equipment failure were 9 scrams (23%) greater than the baseline period average (48 vs. 39). However, when viewed as a percentage of all automatic scrams, the FY 2003 equipment failure scrams were 9% less than the baseline period average (62% vs. 71%).

The next leading cause category is "Other", accounting for 21 (27%) of FY 2003 automatic scrams. This category includes causes such as Procedure, Natural Phenomena, Unknown, and Other (including the grid related events that are outside of the affected plants' control). This category accounted for 13 scrams (163%) greater than the baseline period average (21 vs. 8). The Northeast blackout accounted for 9 of those 13 scrams.

During the baseline period, three systems resulted in more equipment scrams than others: feedwater, main generator, and turbine. This trend continued in FY 2003. In addition to the grid-related scrams discussed above, the main generator accounted for 5 scrams (71%) more than the baseline period average (12 vs. 7). The other systems accounted for a level of scrams similar to their baseline period averages.

Scrams during normal operation continued to dominate the other categories, accounting for 78% of FY 2003 automatic scrams. These figures indicate that the increase in the FY 2003 scrams occurred almost exclusively in the normal operation category.

Of the 103 operating commercial nuclear power plants, 67% are PWRs, and 33% are BWRs. Over the baseline period, PWRs experienced 63% of automatic scrams, and BWRs 37%. FY 2003 data were essentially identical, with PWRs experiencing 62% of auto scrams, and BWRs 38%. This indicates that the increase in automatic scrams was not isolated to a reactor type.

A histogram of the number of plants that experienced different levels of automatic scrams per year was generated. For example, in FY 2003, 39 plants experienced only a single automatic scram. The FY 2003 data exceeded the baseline period average in essentially every level, with no plant exceeding 4 automatic scrams per year. This indicates that the increase in automatic scrams was not isolated to a few plants.

Conclusion

This review identified that a single factor was primarily responsible for the increase in FY 2003 automatic scrams; problems associated with the offsite power grid and/or the plants' interface with the grid resulted in 23 FY 2003 automatic scrams. This included the Northeast blackout event, which resulted in 9 automatic scrams. Without the blackout event, the early-warning and action thresholds for automatic scrams would not have been exceeded, but the increase in FY 2003 automatic scrams (most of which was due to grid-related events) would still be notable. It was also noted that the baseline period from which the thresholds were developed did not include a singular event (such as the blackout) that resulted in multiple scrams. Additionally, relatively few scrams from grid-related events occurred during the baseline period.

SAFETY SYSTEM ACTUATIONS

Safety System Actuations (SSAs) are comprised of challenges to two classes of systems, emergency diesel generators (EDGs) and emergency core cooling systems (ECCS). The criteria that determines an SSA does not align exactly with the criteria for engineered safety feature (ESF) actuation reporting. Rather, SSAs are a subset of ESFs as determined by the type of system and circumstances of the actuation. Certain criteria must be satisfied to classify an actuation event as an SSA, and the classification is not solely restricted to actual safety needs. Basically, an EDG SSA is an event in which the EDG did, or should have, re-powered the associated de-energized emergency bus. An ECCS SSA is an event in which any ECCS actuation signal occurs, valid or not, or any ECCS equipment actuates. In either case, determination of an SSA may require some interpretation of the event report information. For this reason, SSAs are not as strictly objective as scrams.

FY 2003 SSAs were at the highest level since FY 1996 (greater than any year in the FY 1999-2002 baseline period). The early-warning and action thresholds correspond to 35 and 40 SSAs, respectively, for 103 plants (including Davis-Besse). In FY 2003, the industry experienced 41 SSAs, exceeding the thresholds by 6 and 1, respectively, and exceeding the baseline period average (25) by 16 (64%). Note that the August 14, 2003, Northeast blackout event resulted in 12 SSAs. Had this event not occurred, neither of the two thresholds would

have been exceeded, but the increase in FY 2003 SSAs would still be notable, exceeding the baseline period average by 4 SSAs (16%).

Due to the nature of SSAs, it is common for an event to cause both an SSA and a scram, or for an SSA to occur during a scram transient. For example, an EDG SSA and scram can both result from a loss of offsite power. Furthermore, an ECCS SSA can result from the level transient following a scram. During the baseline period, 39% of SSAs occurred with scrams. However, during FY 2003, 68% of SSAs occurred with scrams, indicating that the increase in FY 2003 SSAs was largely driven by the increase in scrams. For example, the events resulting in the 23 automatic scrams caused by problems associated with offsite power grid and/or the plants' interface with the grid also resulted in 19 SSAs.

Both types of SSAs (EDG and ECCS) increased in FY 2003. The FY 2003 EDG SSAs were 7 (47%) greater than the baseline period average (22 vs. 15), and ECCS SSAs were 9 (90%) greater than the baseline period average (19 vs. 10).

Of the 103 operating commercial nuclear power plants, 67% are PWRs and 33% are BWRs. Over the baseline period, PWRs experienced 60% of SSAs, and BWRs 40%. In FY 2003 data, the data reversed, with PWRs experiencing 39% of SSAs, and BWRs 61%. In fact, while FY 2003 PWR SSAs were essentially equal to their baseline period average (16 vs. 15), BWR SSAs were 15 (150%) greater than their baseline period average (25 vs. 10), in part due to automatic scrams at BWRs. This indicates that the increase in FY 2003 SSAs occurred mostly at BWRs.

A histogram of the number of plants that experienced different levels of annual SSAs was generated. For example, in FY 2003, 17 plants experienced only a single SSA. The FY 2003 data exceeded the baseline period average in every category (because there are no counts in the baseline 4/year category, compare the FY2003 4/year category with the baseline 3/year category), with no plant exceeding 4 SSAs per year. This indicates that the increase in SSAs was not isolated to a few plants.

Conclusions

The increase in FY 2003 SSAs was largely driven by the increase in scrams (primarily automatic scrams). The Northeast blackout event resulted in 12 SSAs. Without this event, neither of the two thresholds would have been exceeded. It is noted that the baseline period from which the thresholds were developed did not include a singular event (such as the blackout) that resulted in multiple SSAs.